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PATENT COOPERATION TREATY

PCT/AT2003/000018



PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference R 40767	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/AT2003/000018	International filing date (day/month/year) 20 January 2003 (20.01.2003)	Priority date (day/month/year) 25 January 2002 (25.01.2002)
International Patent Classification (IPC) or national classification and IPC G01R 31/308, 31/311, 31/302, G01N 21/17		
Applicant GORNIK, Erich		

<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of <u>9</u> sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of <u>5</u> sheets.</p>	
<p>3. This report contains indications relating to the following items:</p> <p>I <input checked="" type="checkbox"/> Basis of the report</p> <p>II <input type="checkbox"/> Priority</p> <p>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p>IV <input type="checkbox"/> Lack of unity of invention</p> <p>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p>VI <input type="checkbox"/> Certain documents cited</p> <p>VII <input type="checkbox"/> Certain defects in the international application</p> <p>VIII <input type="checkbox"/> Certain observations on the international application</p>	

Date of submission of the demand 26 July 2003 (26.07.2003)	Date of completion of this report 01 July 2004 (01.07.2004)
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Facsimile No.	Telephone No.

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/AT2003/000018

## I. Basis of the report

## 1. With regard to the elements of the international application:\*

- ☐ the international application as originally filed
- ☒ the description:  
pages \_\_\_\_\_ 1-32 \_\_\_\_\_, as originally filed  
pages \_\_\_\_\_, filed with the demand  
pages \_\_\_\_\_, filed with the letter of \_\_\_\_\_
- ☒ the claims:  
pages \_\_\_\_\_, as originally filed  
pages \_\_\_\_\_, as amended (together with any statement under Article 19  
pages \_\_\_\_\_, filed with the demand  
pages \_\_\_\_\_ 1-32 \_\_\_\_\_, filed with the letter of \_\_\_\_\_ 11 June 2004 (11.06.2004)
- ☒ the drawings:  
pages \_\_\_\_\_ 1/16-16/16 \_\_\_\_\_, as originally filed  
pages \_\_\_\_\_, filed with the demand  
pages \_\_\_\_\_, filed with the letter of \_\_\_\_\_
- ☐ the sequence listing part of the description:  
pages \_\_\_\_\_, as originally filed  
pages \_\_\_\_\_, filed with the demand  
pages \_\_\_\_\_, filed with the letter of \_\_\_\_\_

## 2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language \_\_\_\_\_ which is:

- ☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of the translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

## 3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages \_\_\_\_\_
- ☐ the claims, Nos. \_\_\_\_\_
- ☐ the drawings, sheets/fig \_\_\_\_\_

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).\*\*

\* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rule 70.16 and 70.17).

\*\* Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/AT 03/00018

## I. Basis of the report

1. This report has been drawn on the basis of *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*:

The amendments meet the requirement of PCT Article 34(2)(b) for the following reasons:

Claim 1: see original claims 1 and 2

Claim 19: see original claim 18; page 30; figures 11, 13 and 14

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/AT 03/00018

## V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

## 1. Statement

Novelty (N)	Claims	10-11, 13-15, 17, 23-25, 28	YES
	Claims	1-9, 12, 16, 18-22, 26-27, 29-32	NO
Inventive step (IS)	Claims		YES
	Claims	10-11, 13-15, 17, 23-25, 28	NO
Industrial applicability (IA)	Claims	1-32	YES
	Claims		NO

## 2. Citations and explanations

1. The application relates to the determining of properties of semiconductor devices by optical interference, wherein a reference beam and a probe beam are combined and a two-dimensional image is generated. At least two images of the device are taken in succession in different stress conditions, and are compared.

Reference is made to the following documents:

D1: "Integrated circuit tester using interferometric imaging", Proceedings of the UGIM Symposium, Microelectronics Education for the Future. Twelfth Biennial University/Government/Industry Microelectronics Symposium (Cat. No. 97CH36030), page 107; Rochester, NY, USA, 20-23 July 1997; Donaldson W.R.

D2: "Femtosecond interferometry for analysis of internal bond interface delamination in semiconductor devices", Technical Digest. Summaries of papers presented at the Conference on Lasers and Electro-Optics. Conference Edition. 1998 Technical Digest Series, Vol. 6, San Francisco, CA, USA, 3-8 May 1998; Cartwright A.N.; pages 356-357

D3: DE10047136

D5: DE19840725

D8: "A practical die stress model and its applications in

flip-chip packages"; 2000-05-23; Yifan Guo; Vol. 1;  
pages 393-399

2. Clarity and interpretation of the claims

Claim 1

The wording of claim 1 does not make it clear whether the step in which the changes in the refractive index are produced by differing stress conditions is actually part of the method. Assuming the broadest possible interpretation, the present wording seems to indicate that this step is merely a result which is to be achieved.

Claims 1 to 33

The term "stress" is interpreted in its broadest sense and covers not only mechanical stresses but also (or rather) optical and electrical stresses of all kinds.

Claims 20 to 33

Since these claims relate to apparatus for the optical testing of semiconductor devices, the device itself and hence also its properties are not part of the system, and therefore have little or no limiting effect on the claimed subject matter.

3. Novelty

- 3.1 Document D2 (figure 1; page 356, column 2) discloses a method for the optical testing of semiconductor devices of a certain thickness, wherein a 100-femtosecond laser pulse is directed at the sample. Since the sequential pulses are not phase-coordinated they constitute a light source with a coherence length of one pulse width, i.e.  $100 \times 10^{-15} \times 3 \times 10^8 \text{ m}$  (30 microns). In this way, according to page 356, column 2, lines 10 to 25, it is possible to select one junction region (of several), specifically the junction region whose distance from the beam splitter is the same as the set distance between the beam splitter and

the reference mirror. Since the samples are multilayered semiconductor devices (at least some of which can be selected with a resolution of 30 microns), the method satisfies the condition that the coherence length of the probe beam must be less than the optical path length  $2 \times L \times n$  (where  $L$  is the thickness and  $n$  is the average refractive index of the semiconductor device material). It is also clear from the discussion of figures 2(a), 2(b) and 2(c) in D2 that a number of interference images are detected in succession with the device in different stress conditions (see figures 2(a) and 2(b)), and that a memory (for the images of figures 2(a) and 2(b)) and a unit for automatically comparing the interference (the subtraction from figures 2(a) and 2(b) shown in figure 2(c)) are also provided.

The measuring principle used in D2 corresponds exactly to that described in the present application, inasmuch as essentially only the probe beam that is reflected by a particular junction region (the front of the device) is coherent with the reference beam, so that only this region (or side) is selectively scanned by the resulting interference. Other reflected probe beams (e.g. from the back, from multiple reflections in the device, or from other regions) are not coherently overlaid as background signals in the interference.

Claim 1 therefore fails to meet the requirement of novelty (PCT Article 33(2)).

- 3.2 If claim 1 did actually include the method step in which the changes in the refractive index are produced by differing stress conditions, claim 1 would meet the requirement of novelty in relation to D2. However, apparatus claim 19 does not meet the requirement of novelty on account of the additional phrase "changes in the refractive index in the bulk of the semiconductor device ... external stress" because the sample is not a

feature of the apparatus. Claim 19 is directed to apparatus for testing a sample; whether or not the generated images represent changes in the refractive index in the bulk of the semiconductor device depends on the properties of the semiconductor device sample. However, these properties are not part of the claimed apparatus. Hence the apparatus according to D2 corresponds to the apparatus of claim 19 and would produce this effect when testing semiconductor device samples with refractive indices that are variable under stress.

- 3.3 Claims 2 to 8, 11, 15, 17 to 21, 25 to 26 and 28 to 31 fail to meet the requirement of novelty in the light of the following documents:

- D1 anticipates claims 2 to 4, 6 to 8, 11, 17 to 18, 20 and 28 to 31.
- D2 anticipates claims 2 to 3, 7, 11, 17 to 20 and 28 to 31.
- D3 anticipates claims 2 to 8, 11, 15, 17 to 18, 20 to 21, 25 to 26 and 28 to 29.

4. Inventive step

- 4.1 For the reasons indicated below, the remaining features of the following claims are obvious from the prior art:

Claim 10: polishing the back of the semiconductor device

For a person skilled in the art it is clear from the interference measurement in D1 that stray light must be avoided as far as possible on the back surface at the point of impact of the input beam, and the most obvious way to achieve this is to polish the surface (see document D8).

Claims 11, 23, 13 to 14 and 24 to 25: splitting the light beams and picking up the light using individual detectors;

polarisation or wavelength splitting

It is generally known that an interference image is both polarisation-sensitive and wavelength-sensitive, and it is therefore obvious that additional measurement information can be obtained by taking measurements at different polarisations and different wavelengths.

Claim 15: reference semiconductor device

Figure 1 in D1 shows a silicon reference mirror which has the same form as the silicon substrate which is being examined. In order to optimise the interference, these elements are very probably the same. See also document D8.

Claims 17 and 28: tilting a reference mirror in order to optimise the interference image (contrast)

See document D5.

Claims 10 to 11, 13 to 15, 17, 23 to 25 and 28 therefore fail to meet the requirement of inventive step (PCT Article 33(3)).

- 4.2 If the feature according to which the changes in the refractive index are produced by differing stress conditions was actually included, this could establish the inventiveness of method claim 1.

In this case, the closest prior art would be D1, not D2. D2 deals with the determining of boundary layer properties and makes no reference to changes in the refractive index in the bulk of the semiconductor device, whereas D1 does relate to such changes in the bulk of the semiconductor device in the same way that claim 1 would if clarified as indicated.



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/AT 03/00018

Claim 1 would thus be novel over D1 (as the closest prior art) on account of the following feature:

- (i) determination of changes in the refractive index in the bulk of the semiconductor device by avoiding multiple reflections at the front and back of the semiconductor device by selecting a coherence length of less than  $2 \times L \times n$

Regarding (i):

D1 itself does not give any indication regarding the choice of coherence length or the fact that when making a choice the thickness of the semiconductor device sample should be taken into consideration, since D1 does not acknowledge the problem of multi-beam interference within the semiconductor device if the coherence length is too great in relation to the product of the thickness and the refractive index.

Extracting this teaching from D2 and combining it with D1 is not an obvious step because the method according to D1 does not require the locating of particular layers through the planar sample (as in D2); rather, the method according to D1 involves a volume measurement within the sample via the surface plane of the sample.

**Feld Nr. VIII (iv) ERKLÄRUNG: ERFINDERERKLÄRUNG (nur im Hinblick auf die Bestimmung der Vereinigten Staaten von Amerika)**

*Die Erklärung muß dem in Abschnitt 214 vorgeschriebenen Wortlaut entsprechen; siehe Anmerkungen zu den Feldern VIII, VIII (i) bis (v) (allgemein) und insbesondere die Anmerkungen zum Feld Nr. VIII (iv). Wird dieses Feld nicht benutzt, so sollte dieses Blatt dem Antrag nicht beigelegt werden.*

**Erfindererklärung (Regeln 4.17 Ziffer iv und 51bis.1 Absatz a Ziffer iv)  
im Hinblick auf die Bestimmung der Vereinigten Staaten von Amerika:**

Ich erkläre hiermit an Eides Statt, daß ich nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Erfinder angegeben ist) oder Miterfinder (falls nachstehend mehr als ein Erfinder angegeben ist) des beanspruchten Gegenstandes bin, für den ein Patent beantragt wird.

Diese Erklärung wird im Hinblick auf und als Teil dieser internationalen Anmeldung abgegeben (falls die Erklärung zusammen mit der Anmeldung eingereicht wird).

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Ich erkläre hiermit an Eides Statt, daß mein Wohnsitz, meine Postanschrift und meine Staatsangehörigkeit den neben meinem Namen aufgeführten Angaben entsprechen.

Ich bestätige hiermit, daß ich den Inhalt der oben angegebenen internationalen Anmeldung, einschließlich ihrer Ansprüche, durchgesehen und verstanden habe. Ich habe im Antragsformular dieser internationalen Anmeldung gemäß PCT Regel 4.10 sämtliche Auslandsanmeldungen angegeben und habe nachstehend unter der Überschrift "Frühere Anmeldungen", unter Angabe des Aktenzeichens, des Staates oder Mitglieds der Welthandelsorganisation, des Tages, Monats und Jahres der Anmeldung, sämtliche Anmeldungen für ein Patent bzw. eine Erfinderurkunde in einem anderen Staat als den Vereinigten Staaten von Amerika angegeben, einschließlich aller internationalen PCT-Anmeldungen, die wenigstens ein anderes Land als die Vereinigten Staaten von Amerika bestimmen, deren Anmeldetag dem der Anmeldung, deren Priorität beansprucht wird, vorangeht.

Frühere Anmeldungen: .....

Ich erkenne hiermit meine Pflicht zur Offenbarung jeglicher Informationen an, die nach meinem Wissen zur Prüfung der Patentfähigkeit in Einklang mit Title 37, Code of Federal Regulations, § 1.56 von Belang sind, einschließlich, im Hinblick auf Teilfortsetzungsanmeldungen, Informationen, die im Zeitraum zwischen dem Anmeldetag der früheren Patentanmeldung und dem internationalen PCT-Anmeldedatum der Teilfortsetzungsanmeldung bekannt geworden sind.

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☐ Diese Erklärung wird auf dem folgenden Blatt fortgeführt, "Fortsetzungsblatt für Feld Nr. VIII (iv)".